Run11 RHIC Operation Summary

Haixin Huang

June 23, 2011
RHIC/AGS User Meeting

New Features of Run11 (pp part)

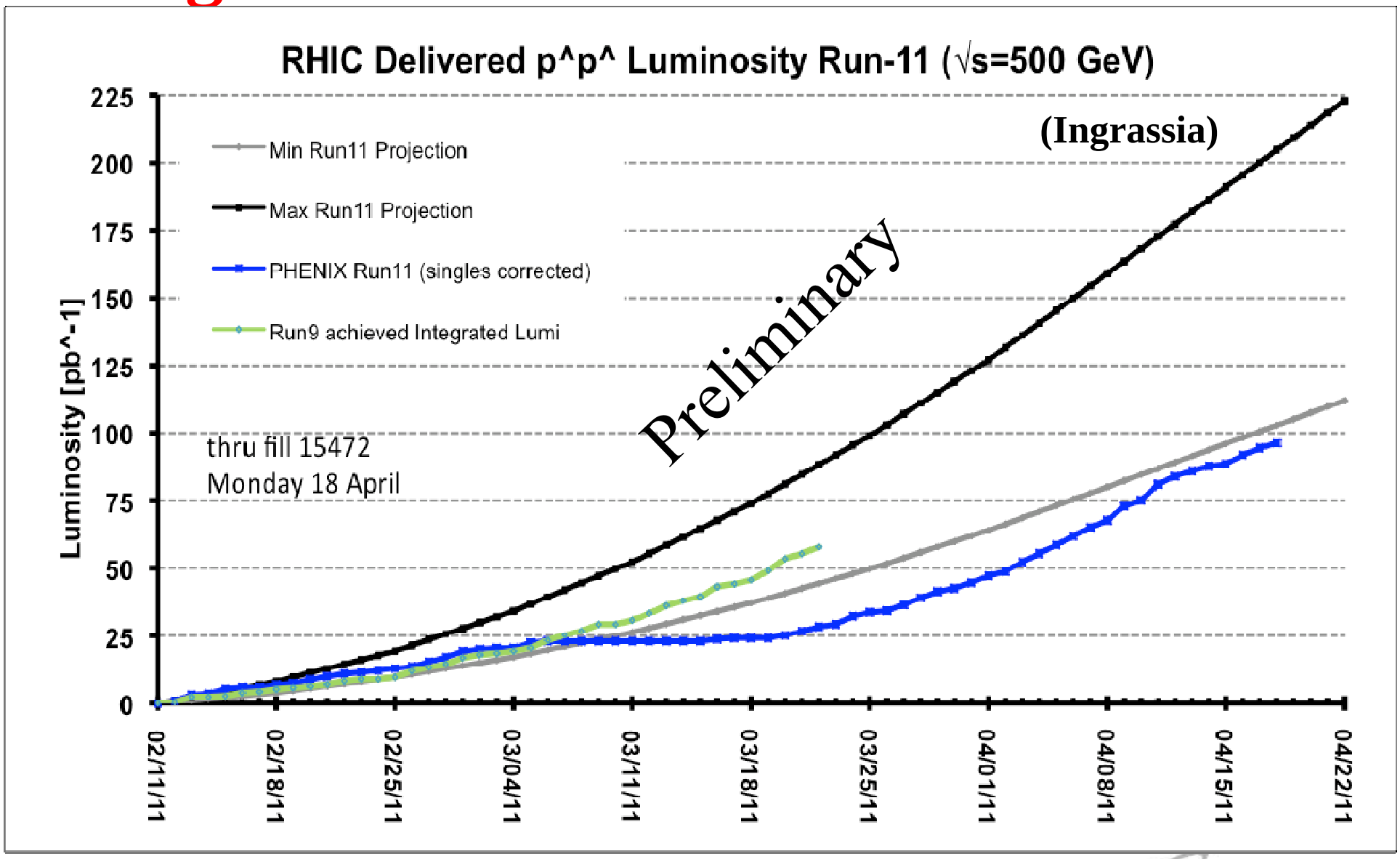
- Vertical survey was done during summer shutdown.
- BPM offset sign reversal was done before the run.
- Beam dump pipe was thickened to avoid down stream magnet quench when dumping high intensity beam.
- 9MHz cavity is ready for use.
- Gamma_tr was lowered by half unit at RHIC injection.
- Slightly smaller beta* was planned.
- New working point (0.680, 0.673).

RHIC Polarized Proton Parameters

Parameters	Goal	Achieved
Interaction points	6 8 2	6 8 2
β* in blue	0.65 0.65 <5	0.8 0.6 3
β* in yellow	0.65 0.65 <5	0.65 0.63 3
Working points	ramp: (28.685, 29.675) Store: (28.69, 29.68)	Ramp: (28.680, 29.673) Store: (28.69, 29.68)
Luminosity/Week	18-32 pb^-1	25.4pb^-1 (the best, 4/5-12)
Polarization	50%	50%*
Peak bunch intensity	1.4*10^11	1.8*10^11
Peak luminosity	1.7* 10^32 cm^-2s^-1	1.6* 10^32 cm^-2s^-1
Emittance	20	23 (on average)
Time in Store	55%	37%

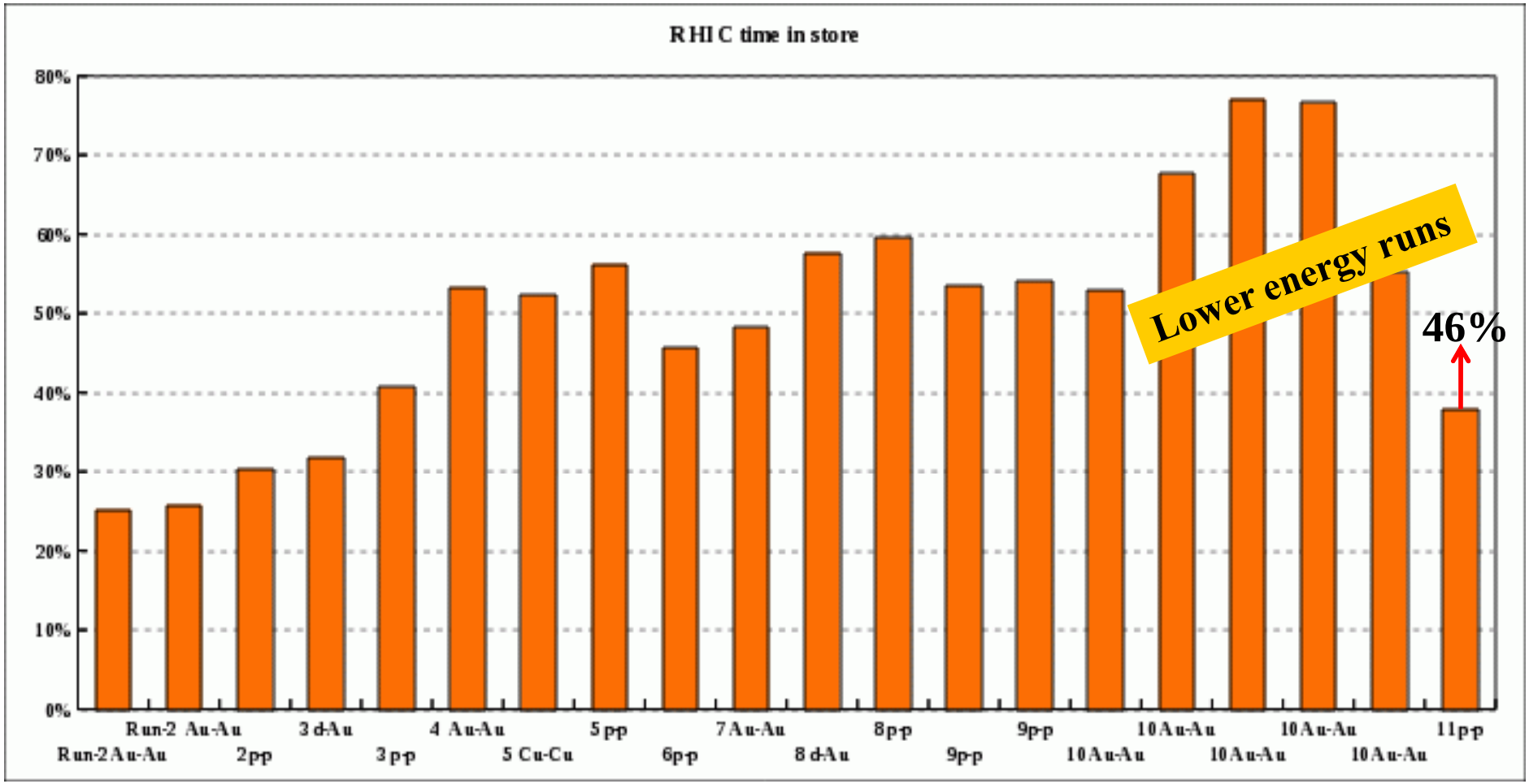
***Average of jet polarization is 46% for both rings. Taking into account for the polarization profile correction factor (R=0.2), The polarization seen by experimenters is boosted by (1+R/2)=> 50%.**

Integrated Luminosities



BROOKHAVEN NATIONAL LABORATORY

Time in Store



Time in store was 37% for run11 pp run. If taking out the two weeks lost due to cryo and power distribution problems, it is still only 46%, compared to the low 50% numbers in last two runs.

It is typical that the second energy or specie has better efficiency.

Time Lost due to Various Reasons

- Blue abort kicker noise. This has been a problem in the past, but it was intermittent. We delayed physics declaration by one week, but the impact of this problem is longer than that.
- Cryo circuit break trips. It happened twice (Feb. 14 and Mar. 6). And took out total of ten days the second time.
- Power distribution problem for injection. This was due to aging cables (more than 40 years?). It took out two days out of operation.
- Pushing vertical tune near 2/3 and controlling snake angle difference requires tune and orbit feedbacks are critical to the operation. There was a learning curve on developing it and using it correctly.
- 9MHz cavity development took longer than expected. 9MHz cavity failure on Apr. 13. We had to lower bunch intensity and recommission the ramp to switch back to 28MHz with lower bunch intensity. Luminosity suffered.

RHIC Beam Intensity

The Run 9 limit on the intensity is gone (largely in yellow).

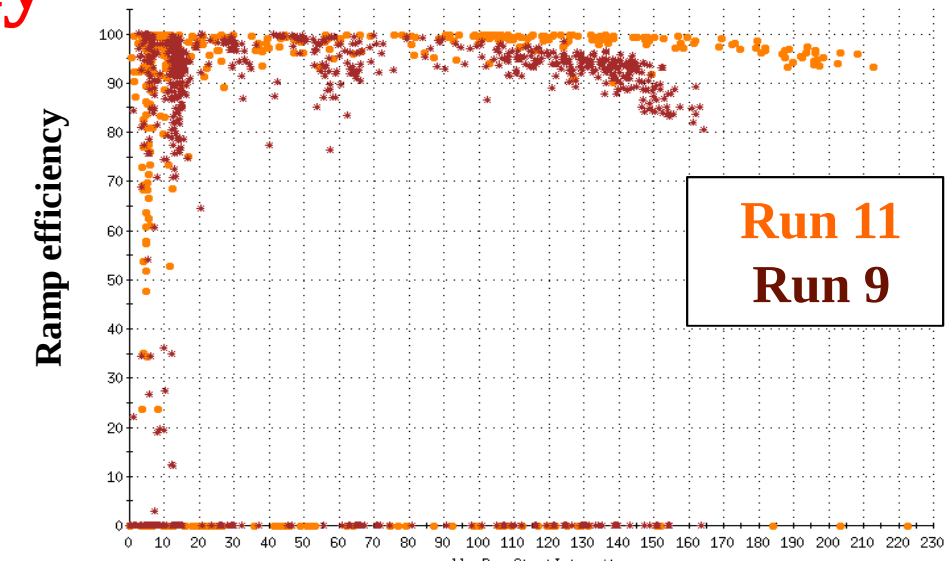
Note that the ramp efficiency was good with 28MHz up to 165e11 in last a few days.

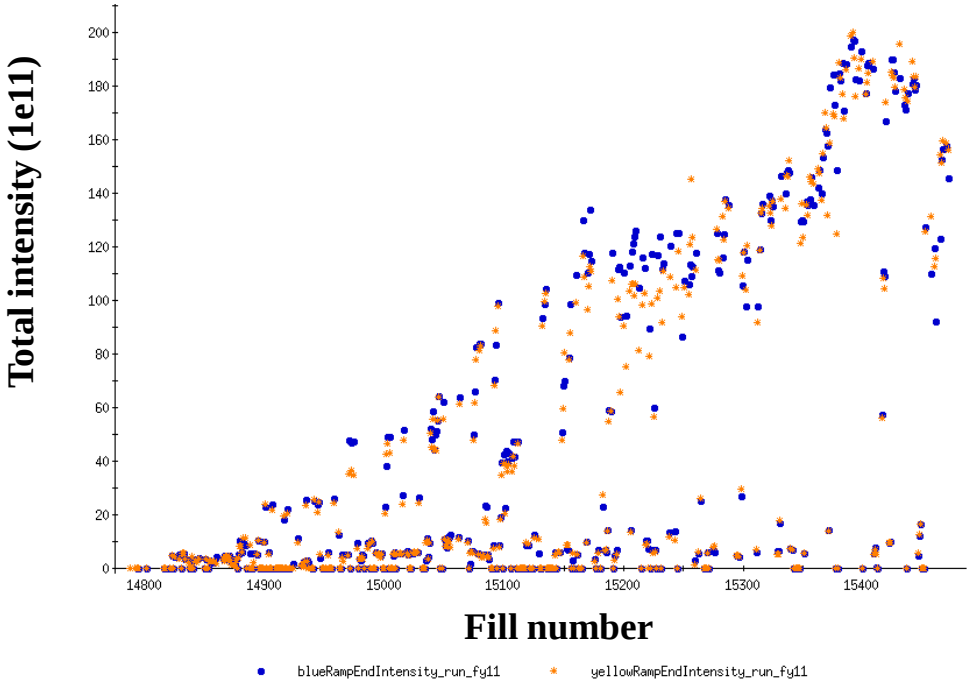
Highest bunch intensity was 1.8e11/bunch at store.

Ramp up

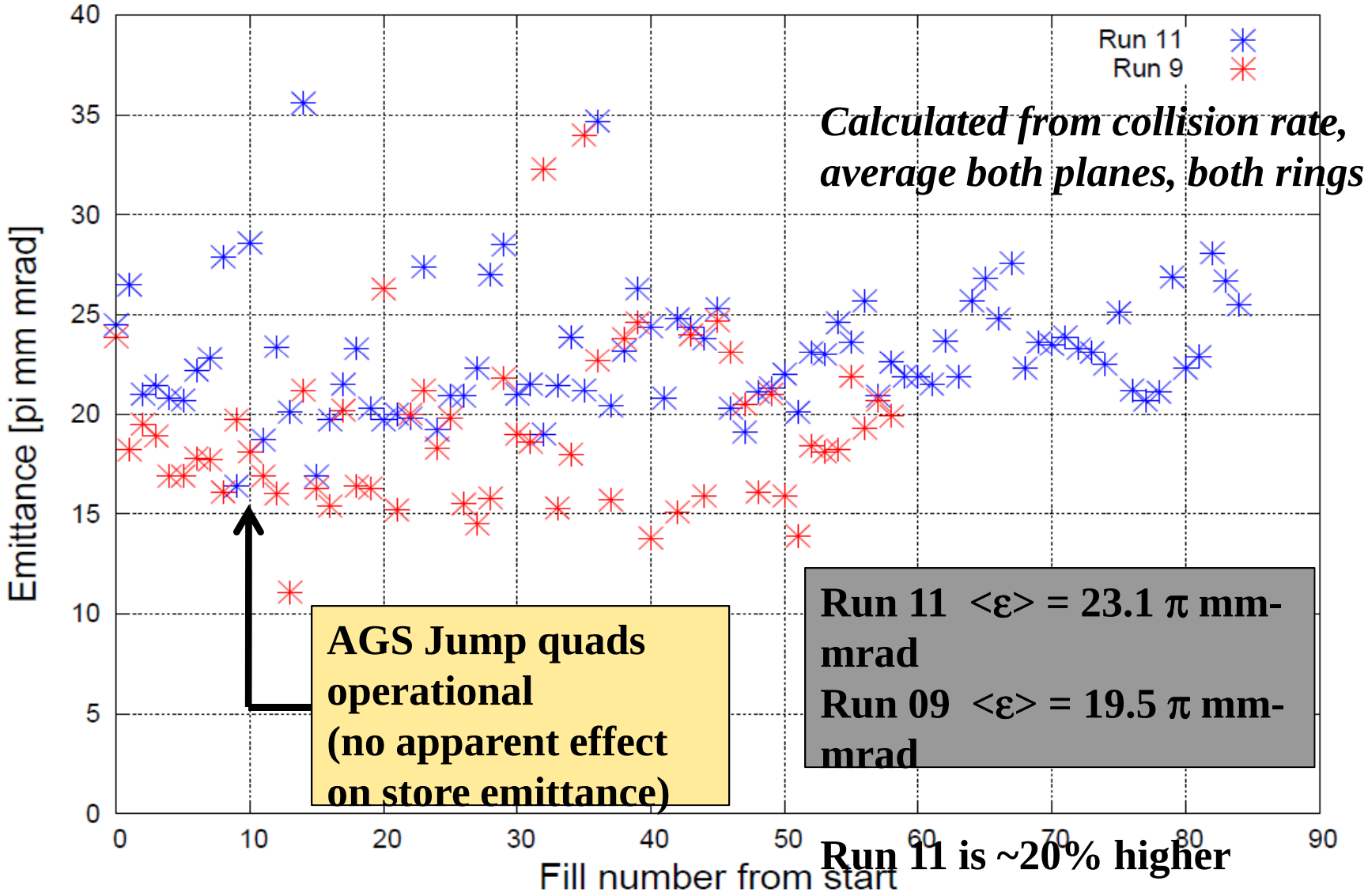
In Run 11 *every* ramp used orbit and tune feedback.

The intensity 'ramp up' strategy could change to take advantage of this. Get to 'physics' faster next run.





Transverse Emittance at Store



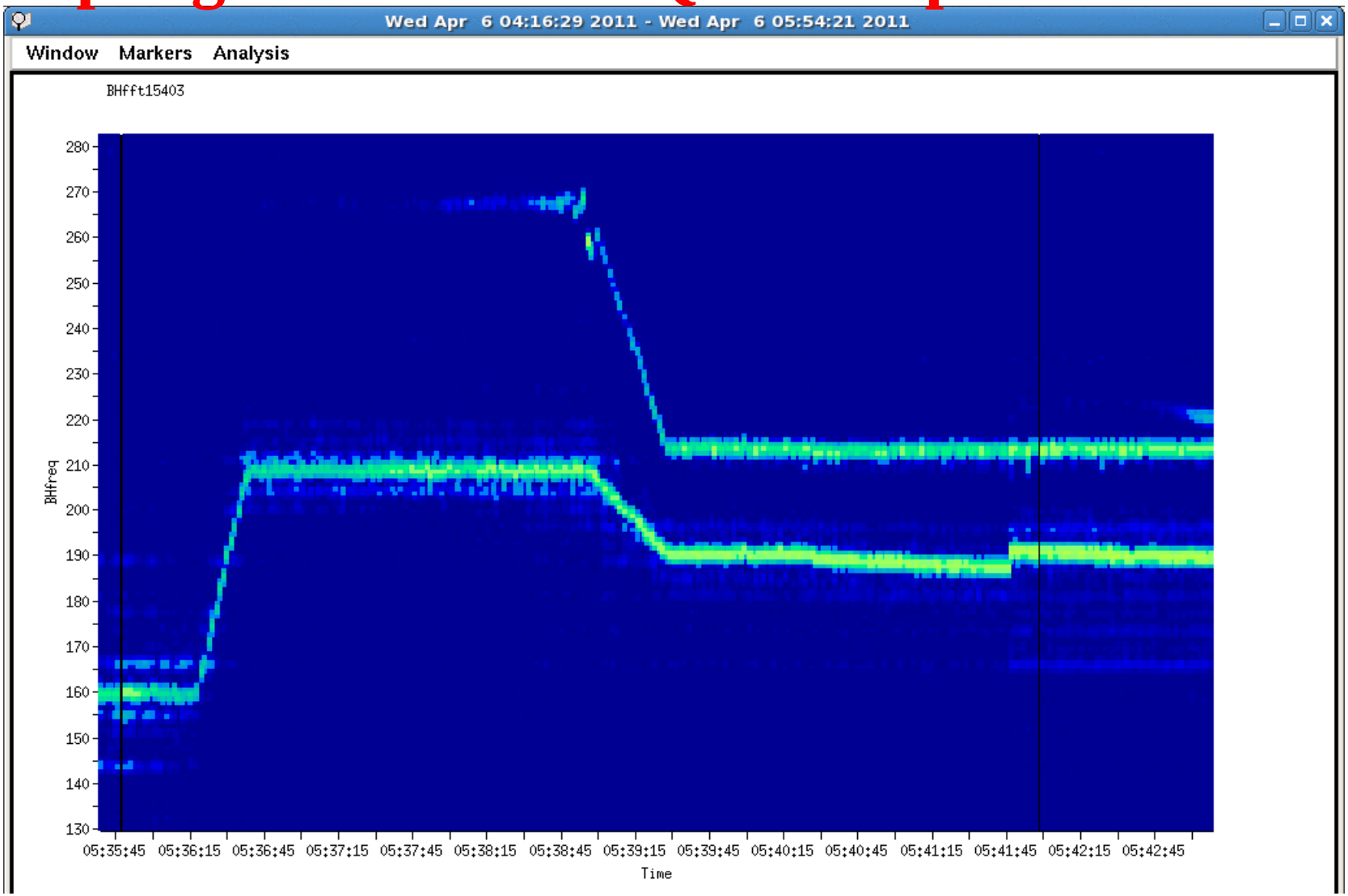
Calculated from collision rate, average both planes, both rings

AGS Jump quads operational (no apparent effect on store emittance)

Run 11 <ε> = 23.1 π mm-mrad
Run 09 <ε> = 19.5 π mm-mrad

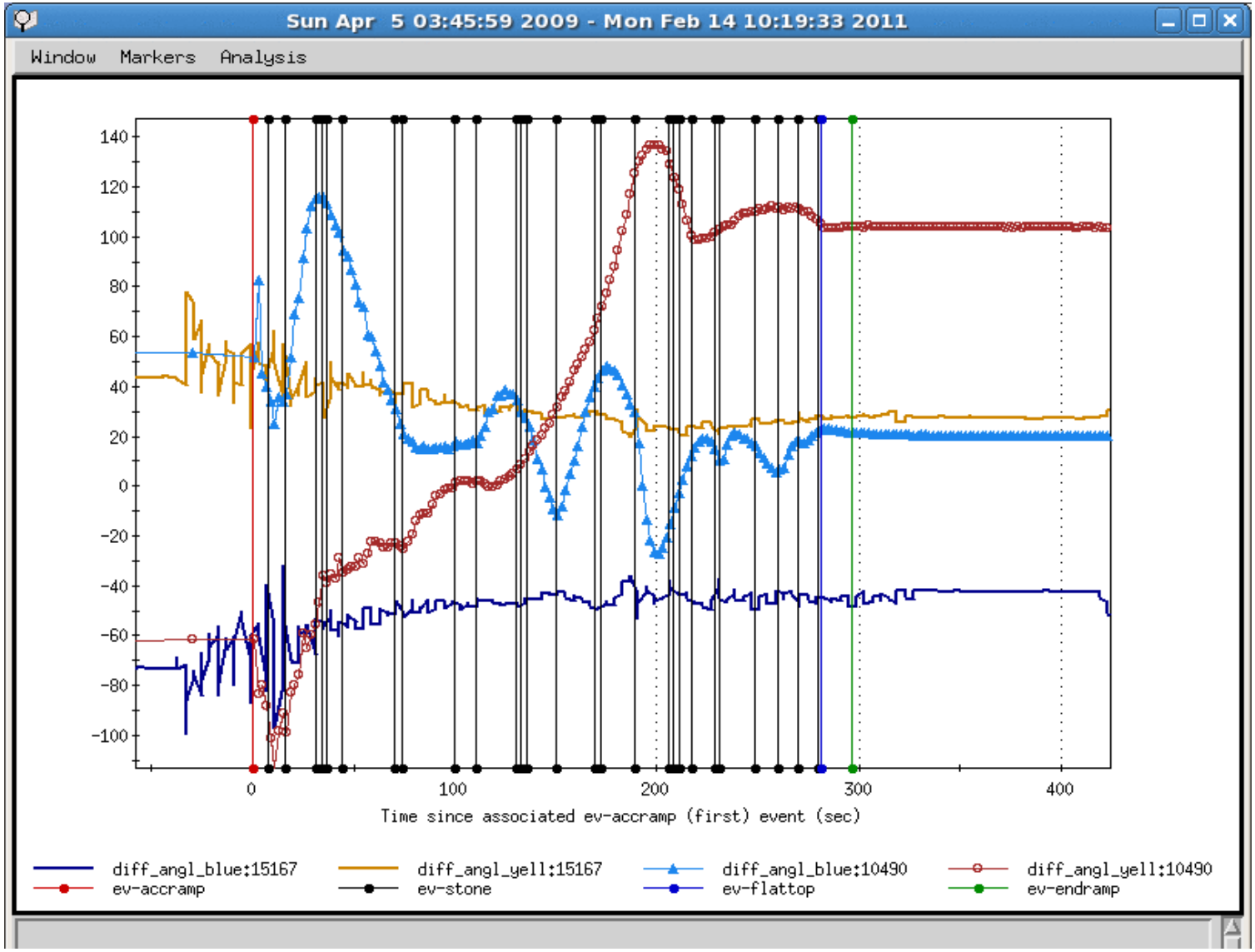
Run 11 is ~20% higher

Coupling Visible on BBQ Tune Spectrum



Coupling is visible on the later part of ramp and at store. A possible source for polarization loss on the ramp and during store (horizontal tune is high, closer to 0.7)

Snake Angle Difference: run11 vs. run9

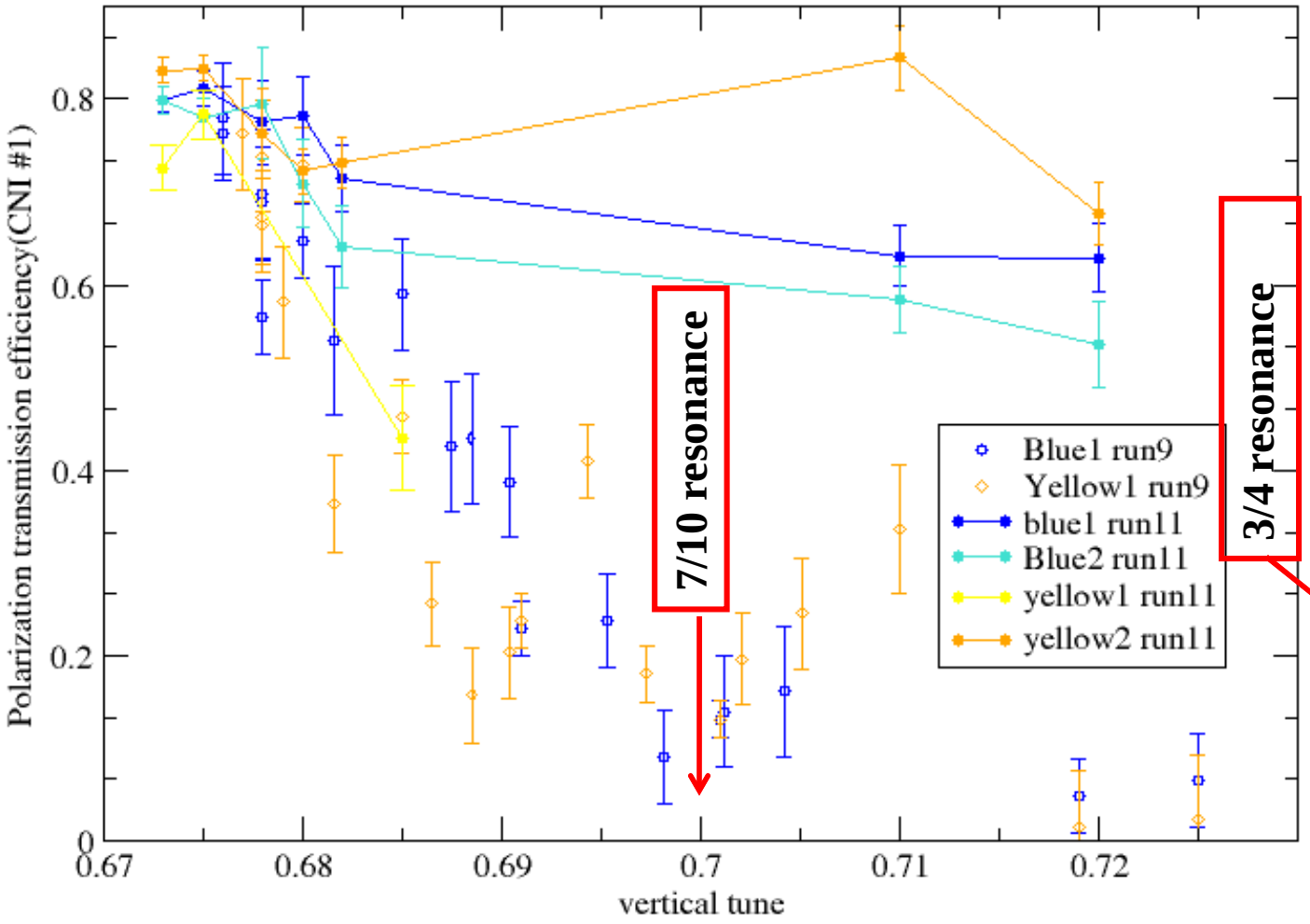


Very significant improvement in run11 due to tune/orbit feedback.

Polarization Sensitivity Tests Done

- We scanned snake current +-5A (+-150mirco-rad), no change of polarization transmission efficiency.
- We scanned the vertical tune on the ramp and it stays at a plateau. Tune control on the ramp is also very good.
- We greatly improved the rms orbit this run through orbit feedback. The BPM offset sign reversal and realignment of vertical should improve the orbit, too.
- Vertical chromaticity is in the 2-3 range over the sensitive range (100-250GeV).
- Possible sources of polarization loss on the ramp: misalignment between magnets and BPMs; coupling at later part of ramp; and horizontal tune/chromaticity because of coupling.

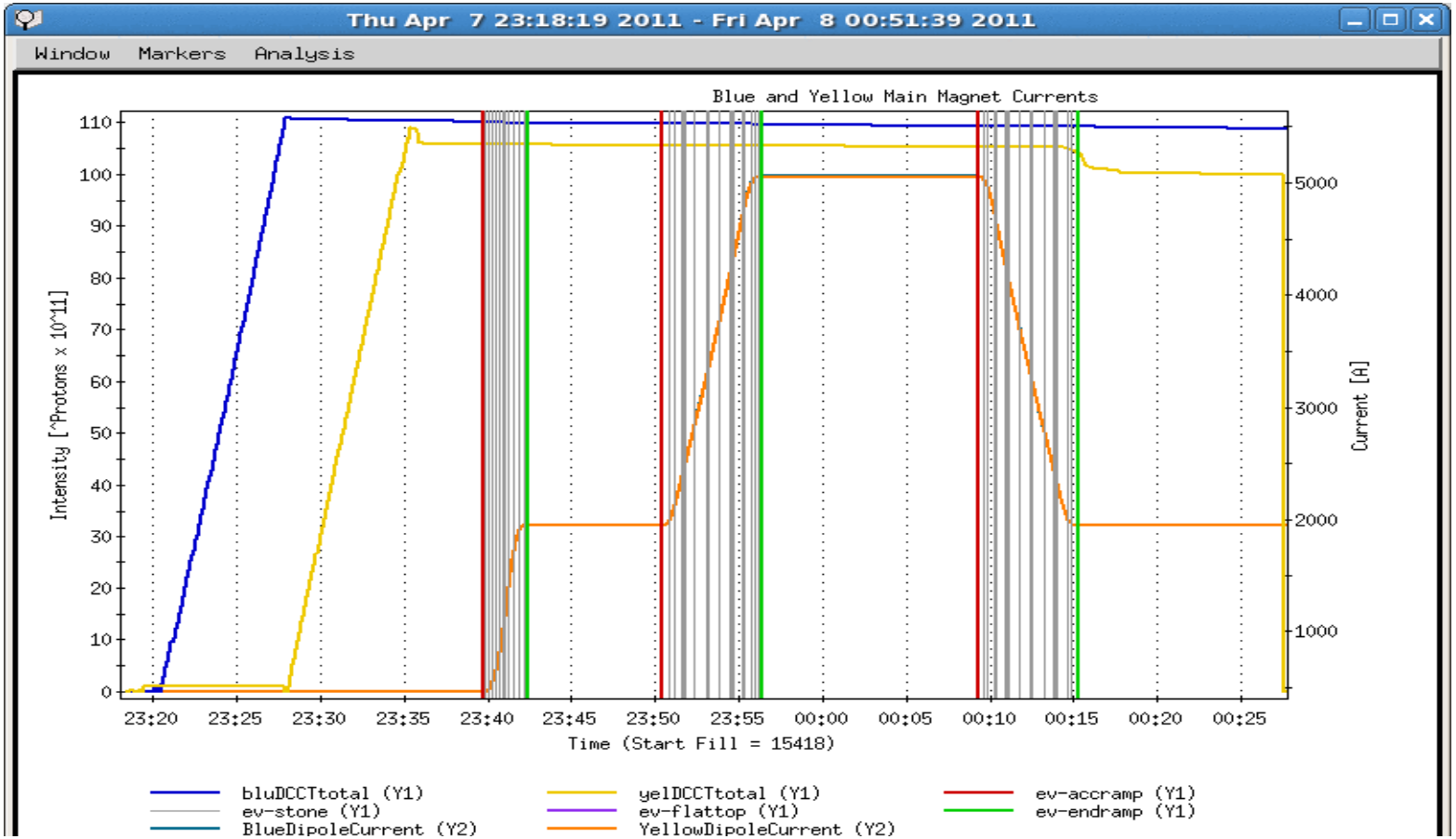
Polarization vs. Vertical Tune on the Ramp



Better efficiency at higher tune (0.71 and 0.72) shows that we have better rms orbit this run. The impact on the polarization at current working point is small, though.

BROOKHAVEN NATIONAL LABORATORY

Down Ramp Development

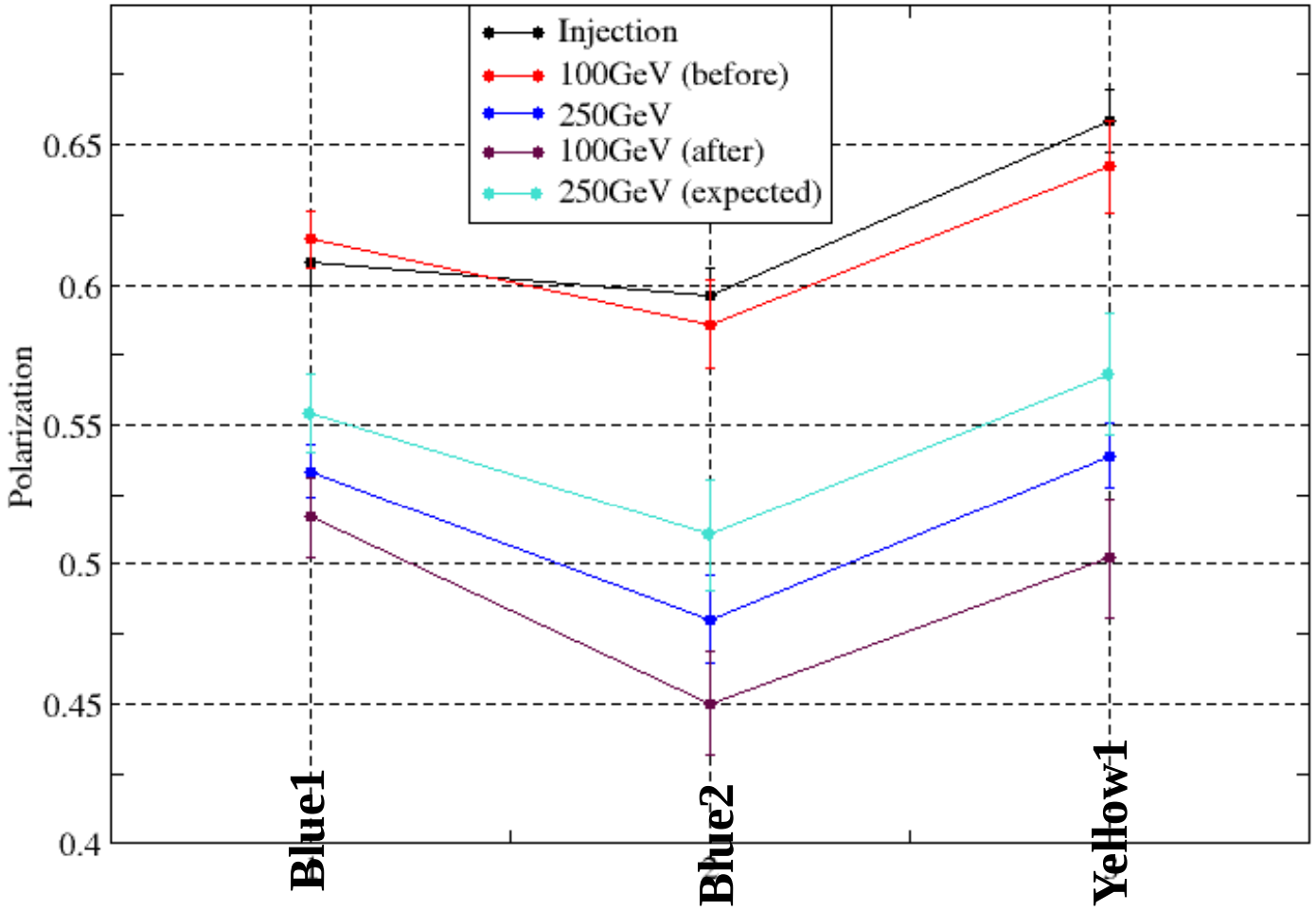


Ratio of polarization @100GeV before and after the two ramps >100:0.783+-0.028

The up/down ramps are confirmed to be identical. So the polarization lost each way is about 10%. With 65% at injection, we expect about 57% polarization at store.

Tune/orbit/coupling/chromaticity feedback was essential for the successful down ramp.

Average Polarization (offline)

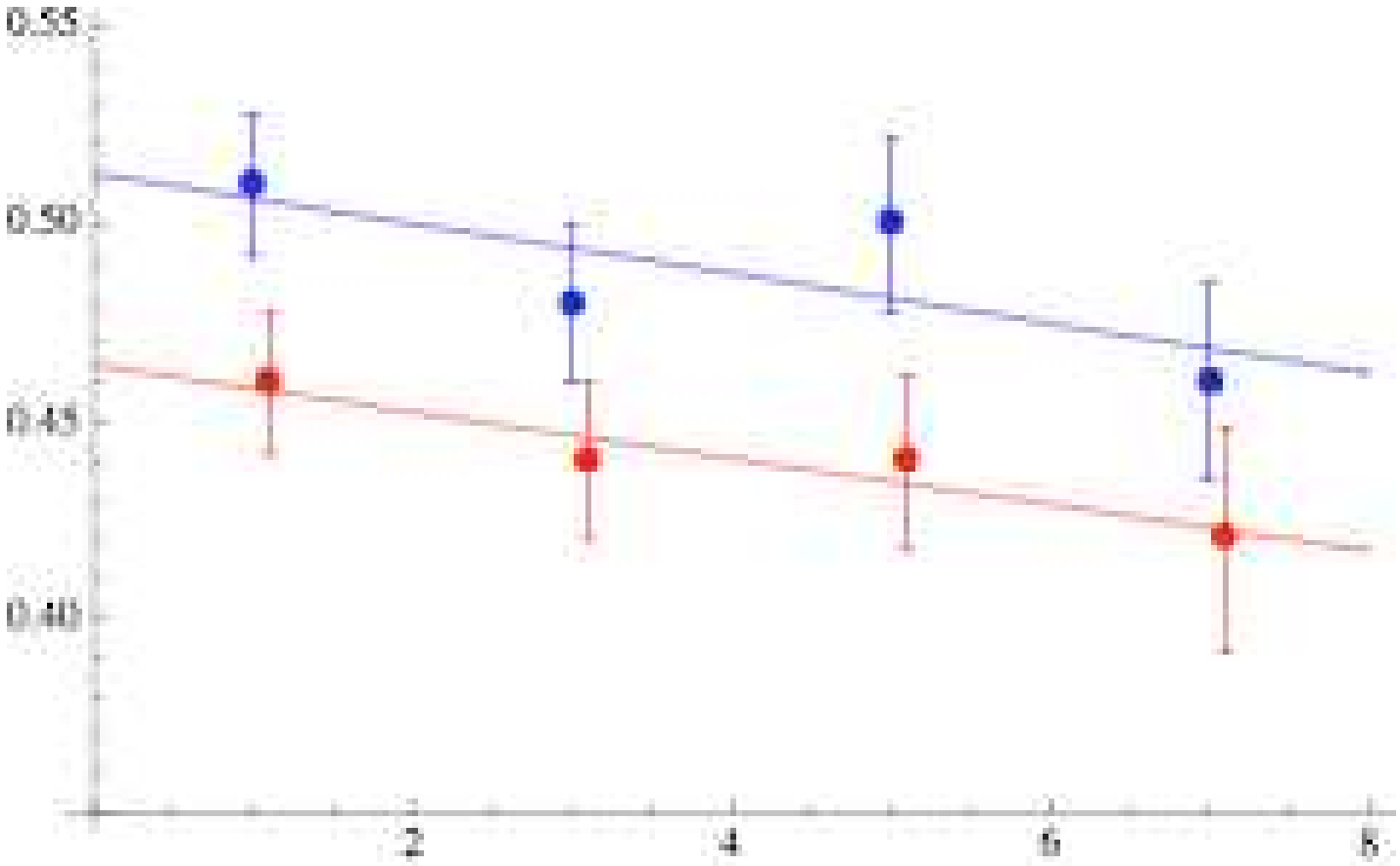


The 250GeV polarization from p-carbon is still lower, but almost within statistical error bars.

The average polarization at beginning of store from p-Carbon is 53% (offline).

This number would suggest a 15% relative polarization loss.

Polarization Decay @ Store



The general polarization loss at store is about 10% (relative) from jet.

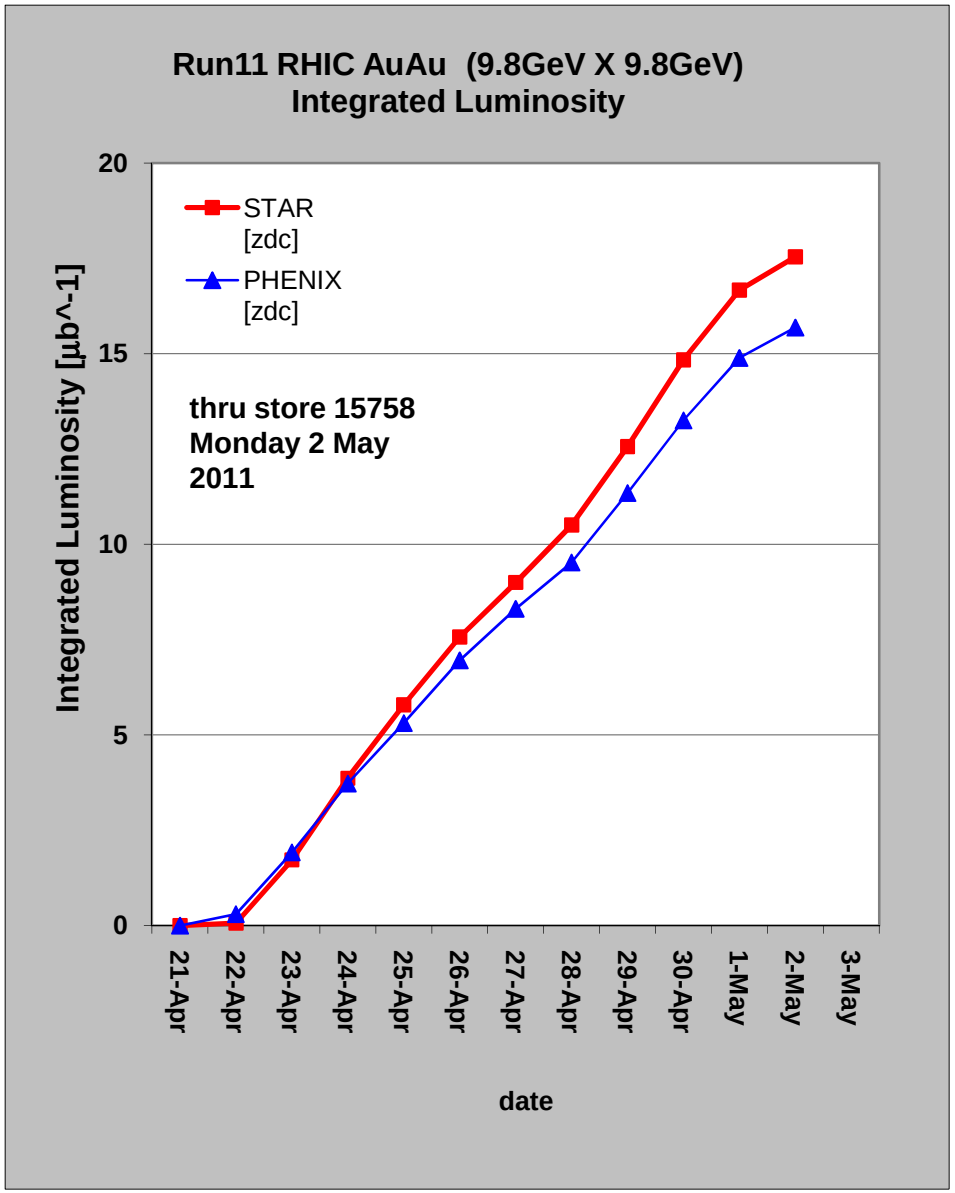
What Has Been Achieved This pp Run

- Higher polarization out of AGS (jump quads).
- Higher polarization at RHIC store (new working point, tune/orbit feedback on the ramp).
- Highest peak luminosity in RHIC so far (9MHz, orbit/tune).
- Orbit feedback works. We have excellent orbit control on the ramp.
- 9MHz cavity is operational. No indication of intensity limit.
- 10Hz orbit feedback works. Beneficial to luminosity.
- Up/Down ramp from 100GeV to 250GeV to compare polarization levels at the two energies.
- Chromaticity feedback works for these ramps. Essential for the down ramp development.
- Injection jet polarization measurement done with a short notice.

Preparation for the Coming Run

- Follow up on various machine availability issues. This will be addressed in the coming RHIC retreat.
- Data mining for the beam parameters vs polarization/luminosity.
- Spin tracking studies with realistic beam conditions to understand the polarization losses.
- Beam physics related issues:
  - Coupling on the later part of ramp and at store;
  - Larger transverse emittances this run.

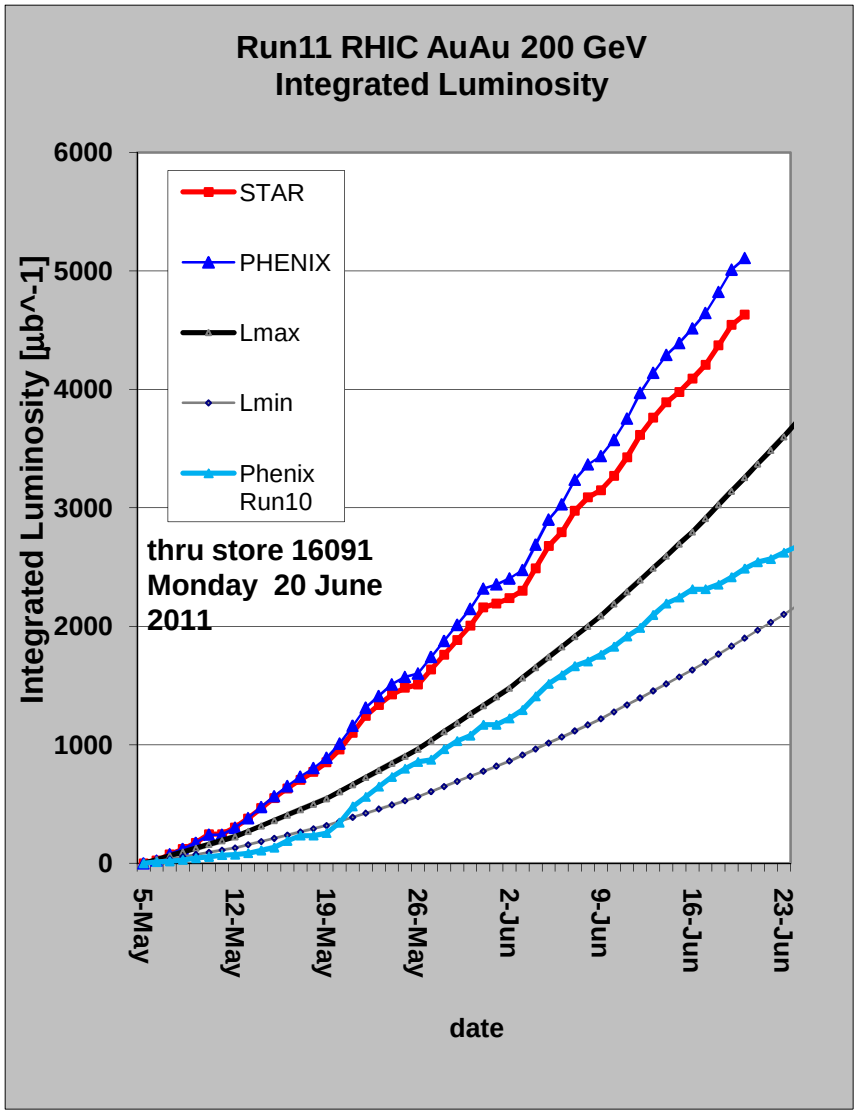
Run-11 Heavy Ions:19.6 GeV Au+Au



- Chosen over original 18 GeV energy due to issue with RF cavity frequency range
  - later solved
- Physics running after 3 days setup
- 71% time in store, second only to 11 GeV in Run-10.
- Met or exceeded most experimental goals

BROOKHAVEN NATIONAL LABORATORY

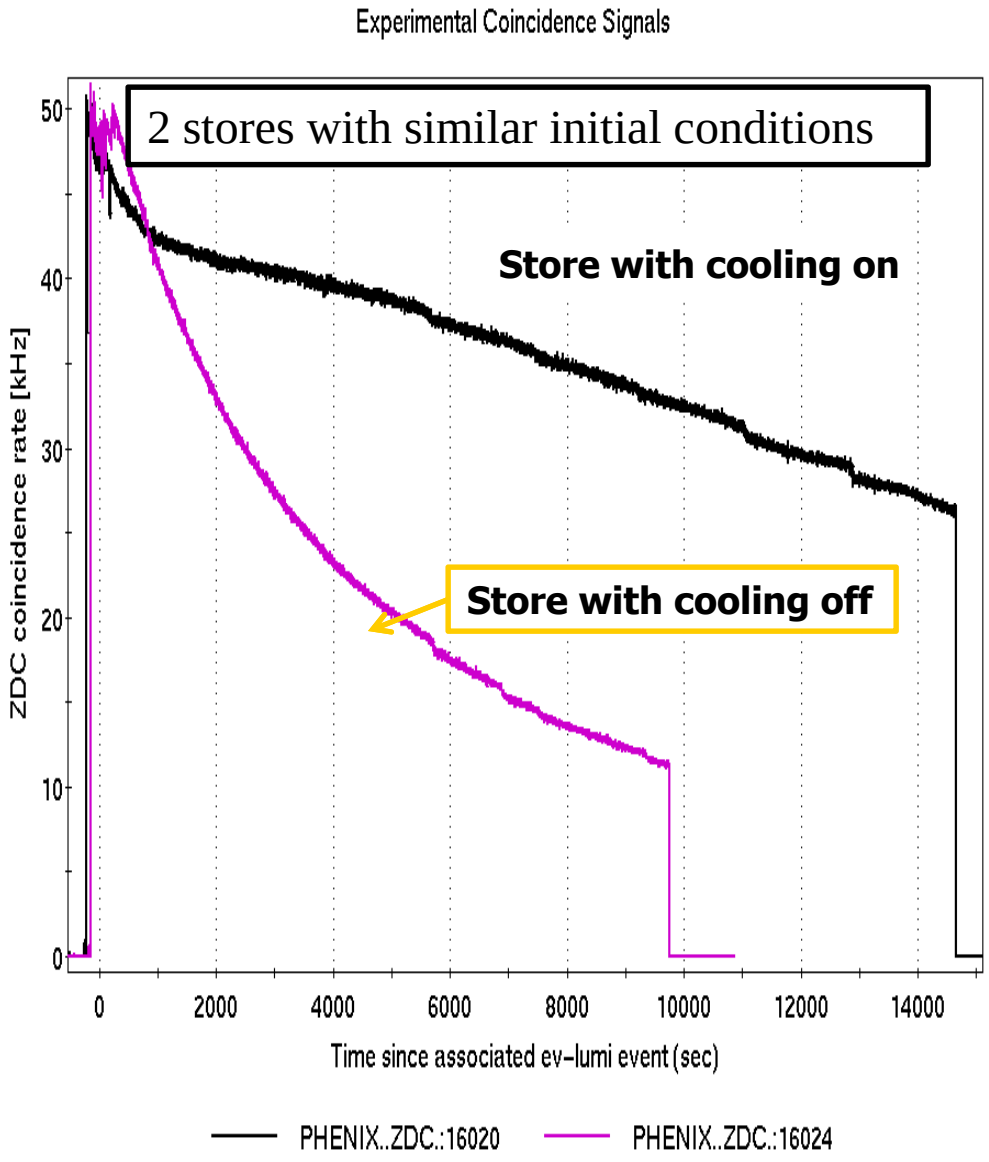
Run-11 Heavy Ions:200 GeV Au+Au



- Both beams accelerated to store in second ramp attempt
- Physics running after 4 days setup
- 59% time in store, equals our best high energy run performances.
- Exceeded most experimental goals, despite abbreviated run length

BROOKHAVEN NATIONAL LABORATORY

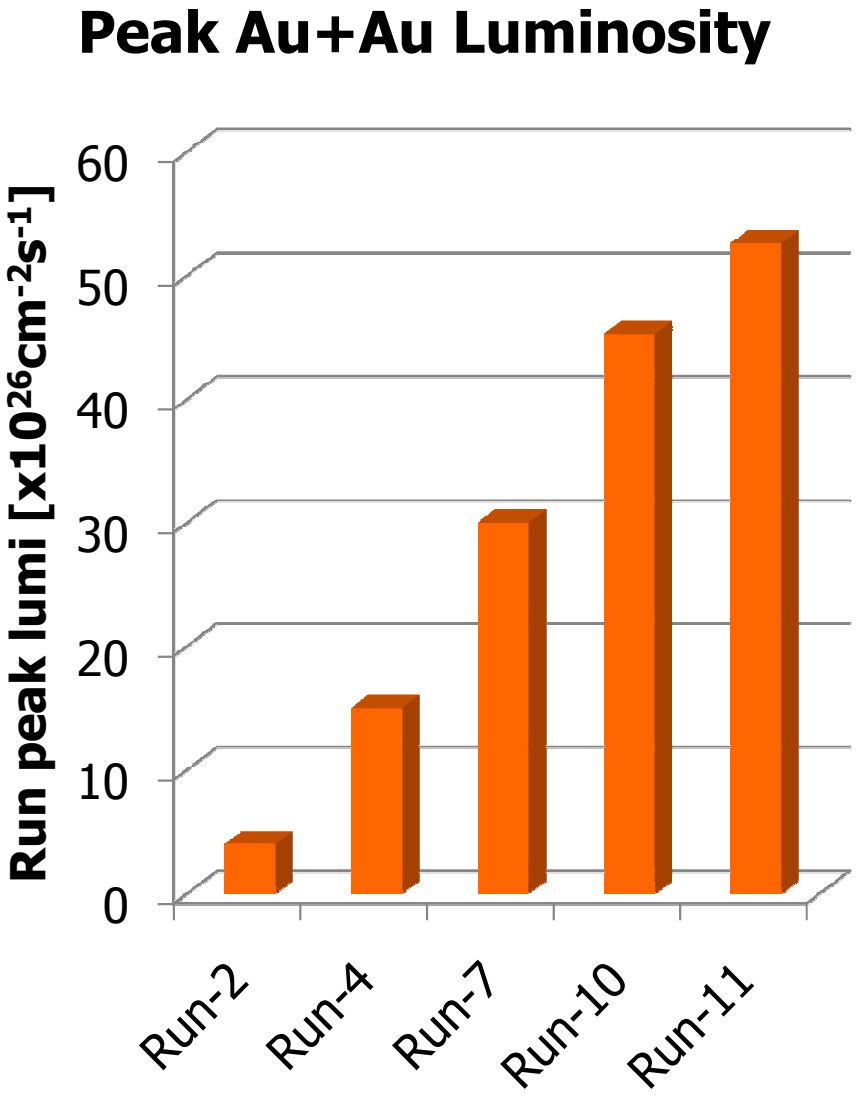
Run-11 Heavy Ion Highlights: Stochastic Cooling



- Stochastic Cooling operational for this run
- Blue and Yellow rings
- Longitudinal and vertical systems running
- Horizontal cooling systems not ready
  - Cooling achieved via transverse coupling

BROOKHAVEN NATIONAL LABORATORY

Run-11 Heavy Ion Peak Luminosity



- Peak luminosities often exceeded last run's best value
- Run-11 best peak (52.6×10^{26} $cm^{-2}s^{-1}$) is a new record for heavy ion colliders.

BROOKHAVEN NATIONAL LABORATORY

Run-11 Heavy Ions: Summary

- All energies benefitted from quick setup times, good availability, rapid store refill times, and relatively low failure rates.
- Machine improvements such as stochastic cooling, relocation of common storage RF cavities, ramp feedback systems, etc. paid off in terms of both instantaneous and integrated luminosity.
- As a result, the run exceeded 200 GeV luminosity projections by a factor 2, and we are able to include a 27 GeV run as well (now in progress).